TRIHALOMETHANES

FACT SHEET

See related Fact Sheets: Acronyms & Abbreviations; Glossary of Terms; Cost Assumptions; Raw Water Composition; Total Plant Costs; and WaTER Program.

1. CONTAMINANT DATA

A. Chemical Data: Trihalomethanes (THMs), are formed from a reaction that produces a "disinfection by-product" from the chlorination of drinking water that contains organic material. THMs are one of a family of organic compounds named as derivatives of methane. The four common THMs are trichloromethane (chloroform) by far the most common in most water systems, dibromochloromethane the most serious cancer risk, dichlorobromomethane, and tribromomethane (bromoform). THMs are colorless volatile liquid with a pleasant odor and a slightly sweet taste, flammable only when it reaches very high temperatures. THMs dissolve easily in water and may break down to other chemicals.

B. Source in Nature: THMs are found naturally in small amounts almost everywhere, most are synthetic. They form when chlorine, used to treat water, reacts with naturally occurring organic materials, such as humic acids from decaying vegetation commonly found in raw water supplies, particularly lakes and reservoirs. Other major sources of THMs in the environment come from chemical and pharmaceutical manufacturing processes such as, the bleaching of wood pulp by paper mills, the disinfection of drinking water, municipal wastewater, and cooling water.

C. SDWA Limits: MCL for total THMs is 0.08 mg/L.

D. Health Effects of Contamination: THMs at short-term exposure levels above the MCL have not shown to cause ill health effects. At long-term exposure levels above the MCL, THMs can cause damage to the nervous system, liver, and kidneys. It can cause sores if large amounts touch the skin. There have been studies that suggest a connection between chlorination by-products and particularly bladder and possibly colon and rectal cancer.

2. REMOVAL TECHNIQUES

A. USEPA BAT: THM control focuses primarily on the removal of THM precursors - natural organic material (NOM), and to a lesser extent, removal of THMs. Removal of NOM prior to chlorination prevents or minimizes the formation of THMs. The most common methods of treatment to control THMs include enhanced coagulation, activated carbon filters, and reverse osmosis.

! Coagulation and filtration for NOM removal uses the conventional treatment processes of chemical addition, coagulation, and dual media filtration. Benefits: low capital costs for proven, reliable process. Limitations: operator care required with chemical usage; sludge disposal.

! THMs and NOM can be reduced by adsorption with an activated carbon filter. GAC uses extremely porous carbon media in a process known as adsorption. As water passes through the media, the dissolved contaminants are attracted and held (adsorbed) on the solid surface. Benefits: well established; suitable for home use. Limitations: effectiveness based on contaminant type, concentration, rate of water usage, and type of carbon used; requires careful monitoring.

! RO for dissolved THMs and NOM uses a semipermeable membrane, and the application of pressure to a concentrated solution which causes water, but not suspended or dissolved solids (soluble THMs), to pass through the membrane. Benefits: produces high quality water. Limitations: high cost; pretreatment/feed pump requirements; concentrate disposal.

B. Alternative Methods of Treatment: Distillation (for home drinking water only) heats water until it turns to steam. The steam travels through a condenser coil where it is cooled and returned to liquid. The THMs remains in the boiler section. Alternately, solid block or precoated absorption filters made with carbon or activated alumina certified to reduce THMs are available.

C. Safety and Health Requirements for Treatment Processes: Personnel involved with demineralization treatment processes should be aware of the chemicals being used (MSDS information), the electrical shock hazards, and the hydraulic pressures required to operate the equipment. General industry safety, health, and self protection practices should be followed, including proper use of tools.

3. BAT PROCESS DESCRIPTION AND COST DATA

General Assumptions: Refer to: Raw Water Composition Fact Sheet for ionic concentrations; and Cost Assumptions Fact Sheet for cost index data and process assumptions. All costs are based on *ENR*, PPI, and BLS cost indices for March 2001. General sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal are not included.

Bureau of Reclamation, Technical Service Center
Water Treatment Engineering and Research Group, D-8230
PO Box 25007, Denver CO 80225 (303) 445-2260
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3A. Enhanced Coagulation and Filtration:

Process - Enhanced coagulation and filtration uses the conventional chemical and physical treatment processes of chemical addition, rapid mix, coagulation, flocculation, and dual media filtration. Chemical coagulation and flocculation consists of decreasing pH (to levels as low as 4 or 5) and increasing the feed rate of a chemical coagulant combined with mechanical flocculation to allow fine suspended and some dissolved solids to clump together (floc). $Fe_2(SO_4)_3$ has been proven to be the most effective coagulant for NOM removal. Floc and other suspended solids are removed by filtration using dual media or mixed media filters.

Pretreatment - Jar tests to determine optimum pH for coagulation, and resulting pH adjustment, may be required.

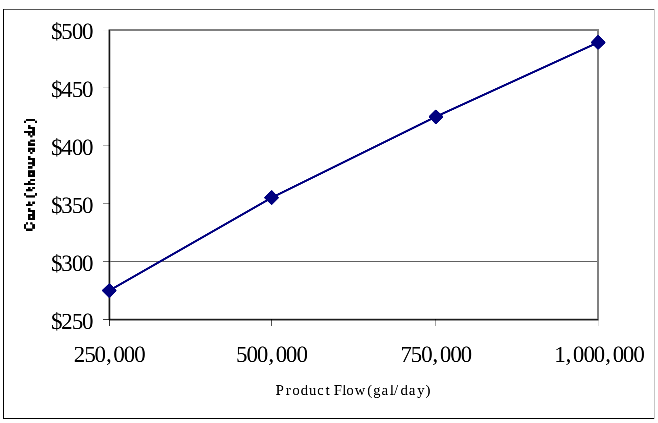
Maintenance - A routine check of chemical feed equipment is necessary several times during each work period to prevent clogging and equipment wear, and to ensure adequate chemical supply. All pumps, valves, and piping must be regularly checked and cleaned to prevent buildup of carbonate scale, which can cause plugging and malfunction. Routine checks of contaminant buildup in the filter is required, as well as filter backwash. Recharging or clean installation of media is periodically required.

Waste Disposal - Filter backwash and spent material require approved disposal.

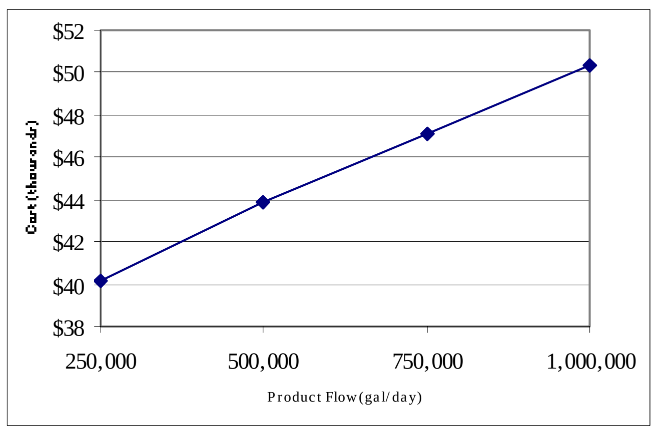
Advantages -
- Lowest capital costs for larger systems.
- Lowest overall operating costs for larger systems.
- Proven and reliable.
- Most effective for NOM removal.

Disadvantages -
- Not appropriate for smaller systems.
- Operator care required with chemical handling.
- High or low pH reduces treatment efficiency; secondary treatment may be required.

BAT Equipment Cost*



BAT Annual O&M Cost*



*Refer to Cost Assumptions Fact Sheet. Does not include general sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal. Costs are presented for direct filtration (coagulation and filtration plus flocculation). Costs for coagulation and filtration would be less since flocculation is omitted.

3B. Granular Activated Carbon:

Process - GAC uses extremely porous carbon media in a process known as adsorption. As water passes through the highly porous media which has an extremely high surface area for adsorption, the dissolved contaminants adsorb on the solid surface. GAC is made of tiny clusters of carbon atoms stacked upon one another. The carbon media is produced by heating the carbon source (generally activated charcoal) in the absence of air to produce a high carbon material. The carbon media is activated by passing oxidizing gases through the material at extremely high temperatures. The activation process produces the pores that result in such high adsorption properties. The adsorption process depends on the following factors: 1) physical properties of the GAC, such as type of raw carbon, method of activation, pore size distribution, and surface area; 2) the chemical/electrical nature of the carbon source or method of activation, and the amount of oxygen and hydrogen associated with them, such that as the carbon surfaces become filled the more actively adsorbed contaminants will displace the less actively adsorbed ones; 3) chemical composition and concentration of contaminants, such as size, similarity, and concentration, affect adsorption; 4) the temperature and pH of the water, in that adsorption usually increases as temperature and pH decreases; and 5) the flowrate and exposure time to the GAC, in that low contaminant concentration and flowrate with extended contact times increase the carbon's life. GAC devices include: pour-through for treating small volumes; faucet-mounted (with or without by-pass) for single point use; in-line (with or without by-pass) for treating large volumes at several faucets; and high-volume commercial units for treating community water supply systems. Careful selection of type of carbon to be used is based on the contaminants in the water, and manufacturer's recommendations.

Pretreatment - With bacterially unstable waters, filtration and disinfection prior to carbon treatment may be required. With high TSS waters, prefiltration may be required.

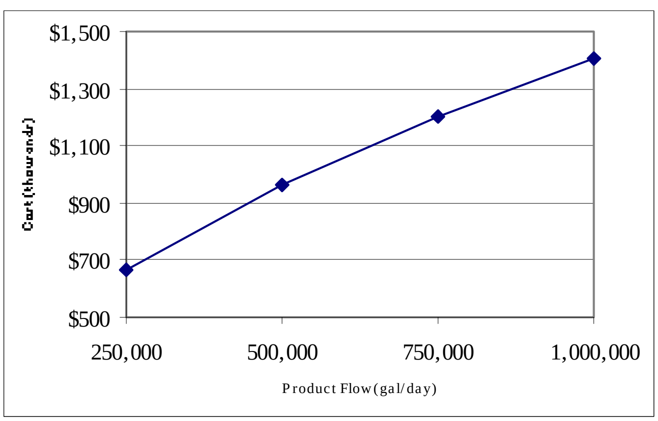
Maintenance - Careful monitoring and testing to ensure contaminant removal is required. Regular replacement of carbon media is required and is based on contaminant type, concentration, rate of water usage, and type of carbon used. The manufacturer's recommendations for media replacement should be consulted. Recharging by backwashing or flushing with hot water (145°F) may release the adsorbed organic chemicals, however this claim is inconclusive. With bacterially unstable waters, monitoring for bacterial growth is required because the adsorbed organic chemicals are a food source for some bacteria. Flushing is required if the carbon filter is not used for several days, and regular backwashing may be required to prevent bacterial growth. Perform system pressure and flowrate checks to verify backwashing capabilities. Perform routine maintenance checks of valves, pipes, and pumps.

Waste Disposal - Backwash/flush water disposal is required if incorporated. Disposal of spent media is the responsibility of the contractor providing the media replacement services.

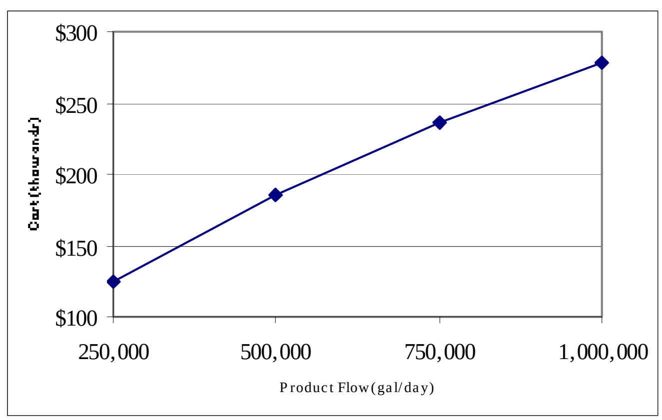
Advantages -
- Well established.
- Suitable for some organic chemicals, some pesticides, and THMs.
- Suitable for home use, typically inexpensive, with simple filter replacement requirements.
- Improves taste and smell; removes chlorine.

Disadvantages -
- Effectiveness is based on contaminant type, concentration, rate of water usage, and type of carbon used.
- Bacteria may grow on carbon surface.
- Adequate water flow and pressure required for backwashing/flushing.
- Requires careful monitoring.

BAT Equipment Cost*



BAT Annual O&M Cost*



*Refer to Cost Assumptions Fact Sheet. Does not include general sitework, building, external pumps/piping, pretreatment, or off-site sludge disposal.

3C. Reverse Osmosis:

Process - RO is a physical process in which contaminants are removed by applying pressure on the feed water to direct it through a semipermeable membrane. The process is the "reverse" of natural osmosis (water diffusion from dilute to concentrated through a semipermeable membrane to equalize ion concentration) as a result of the applied pressure to the concentrated side of the membrane, which overcomes the natural osmotic pressure. RO membranes reject ions based on size and electrical charge. The raw water is typically called feed; the product water is called permeate; and the concentrated reject is called concentrate. Common RO membrane materials include asymmetric cellulose acetate or polyamide thin film composite. Common membrane construction includes spiral wound or hollow fine fiber. Each material and construction method has specific benefits and limitations depending upon the raw water characteristics and pretreatment. A typical large RO installation includes a high pressure feed pump, parallel 1st and 2nd stage membrane elements (in pressure vessels); valving; and feed, permeate, and concentrate piping. All materials and construction methods require regular maintenance. Factors influencing membrane selection are cost, recovery, rejection, raw water characteristics, and pretreatment. Factors influencing performance are raw water characteristics, pressure, temperature, and regular monitoring and maintenance.

Pretreatment - RO requires a careful review of raw water characteristics and pretreatment needs to prevent membranes from fouling, scaling, or other membrane degradation. Removal of suspended solids is necessary to prevent colloidal and bio-fouling, and removal of dissolved solids is necessary to prevent scaling and chemical attack. Large installation pretreatment can include media filters to remove suspended particles; ion exchange softening or antiscalant to remove hardness; temperature and pH adjustment to maintain efficiency; acid to prevent scaling and membrane damage; activated carbon or bisulfite to remove chlorine (postdisinfection may be required); and cartridge (micro) filters to remove some dissolved particles and any remaining suspended particles.

Maintenance - Monitor rejection percentage to ensure THM removal below MCL. Regular monitoring of membrane performance is necessary to determine fouling, scaling, or other membrane degradation. Use of monitoring equations to track membrane performance is recommended. Acidic or caustic solutions are regularly flushed through the system at high volume/low pressure with a cleaning agent to remove fouling and scaling. The system is flushed and returned to service. $NaHSO_3$ is a typical caustic cleaner. RO stages are cleaned sequentially. Frequency of membrane replacement dependent on raw water characteristics, pretreatment, and maintenance.

Waste Disposal - Pretreatment waste streams, concentrate flows, and spent filters and membrane elements all require approved disposal.

Advantages -

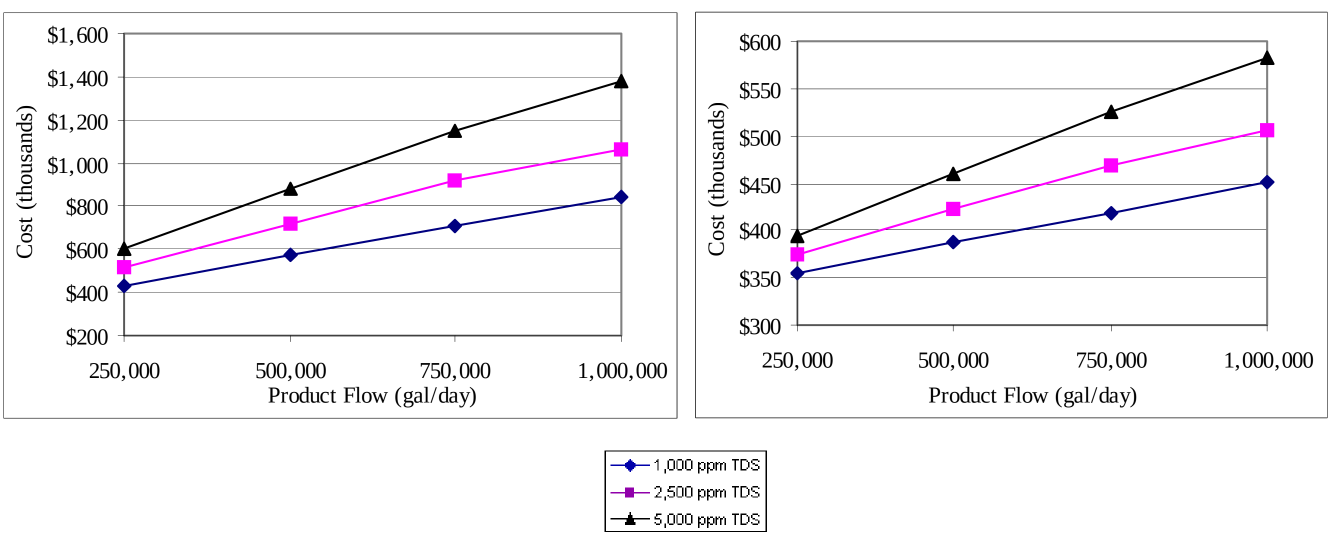
! Produces highest water quality.
! Can effectively treat wide range of dissolved salts and minerals, turbidity, health and aesthetic contaminants, and certain organics; some highly-maintained units are capable of treating biological contaminants.
! Low pressure (<100 psi), compact, self-contained, single membrane units are available for small installations.

Disadvantages -

! Relatively expensive to install and operate.
! Frequent membrane monitoring and maintenance; monitoring of rejection percentage for THM removal.
! Pressure, temperature, and pH requirements to meet membrane tolerances. May be chemically sensitive.

BAT Equipment Cost*

BAT Annual O&M Cost*



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